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FORT BELVOIR, VIRGINIA

CONSTRUCTION MANAGEMENT

STUDENT HANDOUT

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CONSTRUCTION

MANAGEMENT

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CHAPTER 6

EARTHMOVING

6–1. Equipment

Earthmoving may include the following operations: site preparation, excavation and backfill, dredging, and preparing subbase and base. The type of equipment used can have a considerable effect on the man-hours and machine-hours required to complete a given amount of work. Before estimates can be prepared, a decision must be reached on the best method of operation and the type of equipment to be used. Equipment selection should be based as much as possible on efficient operation; however, the availability of equipment is a factor which must also be considered. It is best to utilize any equipment available that can reduce the amount of manual labor required. Since most earthmoving operations can be done by machines with operators, manual labor should be avoided when at all possible.

6–2. Site Preparation

Site preparation includes clearing and grubbing operations (removing, piling, and burning trees and brush, removing stumps, and loading and hauling cut trees and brush) and cut-and-fill earthmoving operations, removing any existing asphalt and concrete structures (paving, walks, and curbs), excavating and hauling from cut areas, and spreading and compacting into fill areas.

6–3. Excavation and Backfill

Excavation and backfill includes the work of trenching and ditching, digging bell holes, excavating for footings and foundations, general excavation, and removing excess earth. It includes trimming and grading, water removal, shoring and bracing, backfilling and compacting, excavating and hauling fill, spreading and compacting fill, and general grading.

6–4. Dredging

Dredging includes preparation of spoil area for dredged material including construction of dikes when required, setting and connecting discharge lines from dredge, dredge operation, barge operation, and disconnecting and removing discharge lines. It also includes underwater excavation with a dragline or clamshell, hauling of dredged material by truck or barge, and disposal of material.

6–5. Preparing Base and Subbase

This includes grading and smoothing, excavating, loading, hauling, spreading, rolling, sprinkling, and fine-grading selected material to form the base and/or subbase. A factor for compaction (15 to 25 percent) should be added to the computed compacted quantity to obtain the quantity of loose material which must be handled.

6–6. Estimating Tables

Tables 6–1 through 6–8 may be used in preparing detailed machine and manpower estimates for earthmoving. Use of these tables should be clear and the results fairly accurate. However, the variables affecting earthmoving are many, and much consideration should be given to situations and conditions varying from the norms these tables are based upon. Included are a table on soil variation conversion factors (table 6–7) and a table on boom swing angle conversion factors (table 6–8). These should be used when necessary. However, these are only two variables of many that must be considered. The conditions and situations will always govern earthmoving estimates.

6–7. Use of Graphic Aids in Estimating

a. The use of graphic aids should be

considered for estimating production rates for any repetitious construction operation that has several definable variables. The variables may be arranged in graphic form as shown in figure 6–1. The graphic form uses the direct reading capability of the nomogram or nomograph to show relative effect of the variables on production.

b. The earthmoving nomograph (fig. 6–1) was constructed by incorporating seven variables into one graphic configuration. Two variables were fixed: capacity at 5 cubic yards per truck and time at 10 hours per day. Time delay per trip, distance, speed, number of trucks, and total volume hauled per day were then progressively locked into the calibrated device, forming this particular (unique) estimator's tool.

c. As an example of the use of this nomograph, find the volume, V, of earth in cubic yards hauled per 10-hour day in 20 trucks, each averaging 5 cubic yards per trip, and with an average time delay of 30 minutes, average speed of 25 miles per hour, and an average haul distance of 7.5 miles.

To find the volume, follow the broken line: 30 – A – B – C – D – E – F.

30 minutes is average time delay, dt, per truck per trip for loading, dumping, maintenance, and contingency during 10-hour workday. Enter nomograph at *dt* of *30*.

25 miles per hour is average speed. Project dt of 30 to 25 mph A; read across to distance equivalent – *12.5* miles B.

7.5 miles is average haul distance. Double for round trip. Combined distance, D, is *27.5* miles C. Project to 25 mph (speed) D.

20 5-yard trucks are used E. Read across to production line, V – cubic yards hauled F as 910 cy/day.

Check by computation:

Let t = Time delay/trip, minutes = 30 minutes
S = Speed = 25 miles per hour
d = Distance one way = 7.5 miles
N = Number of trucks = 20 trucks
Q = Quantity per truckload = 5 cubic yards
H = Hours/day haulage = 10 hours/day
V = Volume hauled/day, cubic yards (cy) = (To be determined)

$$\text{Then } V = \left[\frac{S}{S(\frac{t}{60}) + 2d}\right]\left[NQH\right]$$

$$V = \left[\frac{25\ \frac{mi}{hr}}{25\ \frac{mi}{hr}\ (\frac{30\ min}{60\ \frac{min}{hr}}) + (2 \times 7.5\ mi)}\right]\left[20\ trks \times 5\ \frac{cy}{trk} \times 10\ \frac{hr}{day}\right]$$

$$= \left(\frac{25\ \frac{mi}{hr}}{27.5\ mi}\right) \quad (1000\ \frac{cy - hr}{day})$$

$$= 909.09 --\ \frac{cy}{day} \quad \text{say } 910\ \frac{cy}{day} \quad \text{checks}$$

Table 6–1. Site Preparation – Clearing and Grubbing

Work element description		Equipment	Unit	Hours/unit
Machine work:[1]	(Rates in machine-hours)			
Light clearing		D7E Dozer	1000 sy	0.75
Medium clearing		D7E Dozer	1000 sy	1.80
Difficult clearing:	Tree diameter:			
(For trees and stumps, good conditions, good traction, no steep slopes.)	8 – 12"	D7E Dozer	10 each	0.8 – 2.5
	13 – 24"		10 each	3.0 – 5.0
	25 – 36"		10 each	5.0 – 10
Hand work:[2]	(Rates in man-hours)			Man-hours/unit
Light clearing		Axes, brushhooks, hatchets, machetes	100 sy	2.50
Medium clearing		Axes, cross saws	100 sy	5.00
Cutting large trees:	Tree diameter:	Axes, cross saws		
Removing branches, cutting into short lengths	8 – 12"		each	9 – 12
	13 – 18"	Crew = 4 men	each	12 – 16
	19 – 24"		each	20 – 24
	25 – 36"		each	26 – 30
	8 – 12"	Chain saws, axes	each	2 – 3
	13 – 18"	Crew = 3 men	each	3 – 4
	19 – 24"		each	5 – 6
	25 – 36"		each	6 – 8
Removing stumps	8 – 12"	Picks, shovels, axes	each	8
	13 – 18"	Crew = 3 men	each	10
	19 – 24"		each	12
	25 – 36"		each	15
Blasting trees		Demo	10 each	1.5
Blasting stumps		Demo, sledge hammer, priming stake. Crew = 3 men	each	1.00
Piling and burning		Labor	100 sy	0.80

[1] Typical crew: 1 crew leader, 1 dozer operator, 2–5 men with chain saws and axes cutting and trimming.
[2] Typical crew: 1 crew leader, 4–8 men with brushhooks and axes, 1–2 men with portable chain saws, 2–5 men burning.

Table 6–2. Site Preparation – Earthmoving, Cut and Fill[1]

Work element description	Equipment	Unit	Hours/unit
Machine work: (Rates in machine-hours)			
Excavate and load into trucks			
One-way distance: 50 feet	Power shovel – 3/4 yard[2]	1000 cy	9
	Dragline – 3/4 yard[2]	1000 cy	12
	Clamshell – 3/4 yard[2]	1000 cy	17
100 feet	Scoop loader – 2 1/2 yards	1000 cy	3.5
200 feet	Scoop loader – 2 1/2 yards	1000 cy	5.2
300 feet	Scoop loader – 2 1/2 yards	1000 cy	7.1
	Scoop loader – 2 1/2 yards	1000 cy	10.4
Haul in trucks: (Assume 6 cy per truck, approximately 4 cycles per hour)	5-ton dump[3]	1000 cy	42
Excavate, load, haul: (Round trip) cycle time: 3 minutes	18 yard scraper	1000 cy	3.5
5 minutes	18 yard scraper	1000 cy	5.6
7 minutes	18 yard scraper	1000 cy	7.8
10 minutes	18 yard scraper	1000 cy	11.1
Strip topsoil/stockpile soil, shallow excavation	D7E dozer	1000 cy	37
Spread fill	D7E dozer	1000 cy	16
Sprinkle	1000-gallon distributor	1000 sy	0.04
Compact	Sheepsfoot roller	1000 sy	0.19
2 passes	113 inches wide (2 rollers)	1000 sy	0.39
4 passes		1000 sy	0.58
6 passes			

[1] Crew: crew leader and machine operators/dumptruck drivers as required or available.
[2] See table 6–8 for conversion factors for swing angle.
[3] To use for other than 4 trips/hour, calculate cycle time and use appropriate proportion.

Example: Cycle time of 20 minutes = 3 trips/hour. Then (4 trips/hour) (42 hours) = (3 trips/hour) (? hour) and ? = 56 equipment hours/1000 cy.

Table 6–3. Trenching, Ditching and Backfilling

Work element description		Equipment	Unit	Hours/unit
Machine work:[1] (Rates in machine-hours)				
Trench and ditch excavation		Model 750 ditcher	1000 cy	2.9
Backfill		CAT 12 grader	1000 cy	2
Compact	2 passes	Sheepsfoot roller	1000 sy	0.19
	4 passes	10 feet wide (2 rollers)	1000 sy	0.39
	6 passes		1000 sy	0.58
"V" ditching	Easy	CAT 12 grader	1000 cy	4
	Medium	CAT 12 grader	1000 cy	6.7
	Hard	CAT 12 grader	1000 cy	11.8
Hand work:[2] (Rates in man-hours)				Man-hours/unit
Excavation (6 feet maximum depth)		Shovels, picks	cy	1.75
Bell holes			10 each	1
Backfill		Shovels	cy	0.75
Tamp		Pneumatic tamp	cy	0.7
Shoring walls	Excavation depth:			
	5 – 8 feet	Sheet piling, lumber, nails,	100 sf	16
	10 – 15 feet	hammers, saws	100 sf	20

[1] Crew: 1 crew leader and operators as required or as available.
[2] Typical crew: 1 crew leader, 2–10 men excavating, 1–2 men bell holes, 2–8 men backfilling and tamping.

Table 6–4. Excavation for Footings and Foundations and General Excavation

Work element description		Equipment	Unit	Hours/unit
Machine work:[1]	(Rates in machine-hours)			
Excavate and load into trucks		Power shovel – 3/4 yard[2]	1000 cy	9
		Dragline – 3/4 yard[2]	1000 cy	12
		Clamshell – 3/4 yard[2]	1000 cy	17
	One-way distance: 50 feet	Scoop loader – 2 1/2 yards	1000 cy	2.7
	100 feet	Scoop loader – 2 1/2 yards	1000 cy	4
	200 feet	Scoop loader – 2 1/2 yards	1000 cy	5.4
	300 feet	Scoop loader – 2 1/2 yards	1000 cy	8
Trimming		CAT 12 grader	1000 cy	6.7
Haul with trucks: (Assume 6 cy/truck, approximately 4 round trips/hr)		5-ton dump	1000 cy	42
Spread spoil pile		D7E dozer	1000 cy	15.4
Spread excess earth		D7E dozer	1000 cy	28.6
Backfill		D7E dozer	1000 cy	18.2
Compact	2 passes	Sheepsfoot roller	1000 sy	0.19
	4 passes	2–40 inch rollers	1000 sy	0.39
	6 passes	abreast	1000 sy	0.58
Grading: (Digging side ditches, shaping crown, smoothing, etc) 4 round trips		CAT 12 grader	1000 sy	0.1
Hand work:[3]	(Rates in man-hours)			Man-hours/unit
Excavate and load into trucks		Picks, shovels	cy	3
Spread loose soil		Shovels	cy	0.33
Backfill, shovel only		Shovels	cy	1.33
Backfill and tamp		Shovels, pneumatic tamp	cy	2.5
Haul up to 150 feet		Wheelbarrow	cy	1
Trim and fine grade		Shovels, rakes	100 sy	2
Shoring for basements, foundations, etc. Depth:	8–12 feet	Lumber, sheet piling,	100 sf	25
	14–20 feet	nails, hammers, saws	100 sf	30
	8–12 feet	With pneumatic hammers	100 sf	21
	14–20 feet	With pneumatic hammers	100 sf	26

[1] Typical crew: 1 crew leader, 2 men on excavation equipment, 2–6 men on haul equipment, 1 man on compact equipment, 1 man on grading equipment.
[2] See table 6–8 for conversion factors for swing angle.
[3] Typical crew: 1 crew leader, 2–10 men excavating, loading, spreading, backfilling, compacting, trimming, fine grading, tamping; 2 or more men shoring.

Chapter 7

missing

CHAPTER 8

CONCRETE

8–1. General

This chapter deals with the installation of cast-in-place concrete, except paving and sidewalks, which are discussed in chapter 7. Concrete construction usually requires forming, reinforcing, mixing concrete, placing concrete, finishing concrete, stripping forms, and curing concrete. In addition, some concrete construction requires fine grading, vapor barriers, expansion joints, cold weather protection, and the placing of embedded anchors in the concrete.

8–2. Forming

Forming is usually computed in square feet of contact surface (SFCS), which is the area of concrete in direct contact with forms, or in lineal feet (lf) of form required. Screed guides should be computed as the equivalent form area of an edge form the normal thickness of the slab. Labor required for forming includes fabrication, handling into place, erection, and oiling; installing form ties, tie wire, struts, chamfer strips, screed guides, bracing, and shoring; erecting runways and scaffolds; and checking forms during placement of concrete. Stripping includes removing, cleaning, and reconditioning forms.

8–3. Reinforcing

Concrete is reinforced with reinforcing steel bars, or with welded steel wire mesh which is used for reinforcing slabs, gunite, and precast concrete. In a few instances mesh and bars are used in combination for reinforcing. Some of the tables show both bars and mesh, so that the appropriate man-hours per unit may be used. Reinforcing steel is computed in tons of bars, and reinforcing mesh is computed in square feet of area. Labor for reinforcing steel includes handling into place, tying, supporting, and any cutting which becomes necessary at the site, such as cutting around embedded materials or cutting stock lengths of straight bars to fit slab dimensions. Labor for wire mesh reinforcing includes handling into place, cutting to fit, tying at overlaps, and pulling up into position during placement of concrete.

8–4. Mixing Concrete

Sometimes concrete must be mixed at the jobsite rather than being delivered in transit-mix trucks. Labor for mixing concrete at the jobsite includes loading, measuring, wheeling, and dumping aggregates and cement into mixer; bringing water to the mixer by truck, hose, pipe, or pump; and operating the mixer.

8–5. Placing Concrete

Labor for placing concrete includes the handling of concrete from the mixer or transit-mix truck to final position, including hoisting, spreading, vibrating, and screeding to grade.

8–6. Finishing Concrete

Labor for finishing includes the work of floating, troweling, and tooling slabs; and filling voids and honeycombs. Pointing and patching includes patching tie holes and removing fins.

8–7. Curing Concrete

Labor for curing includes covering surfaces with curing compound, or with sand, paper, tarpaulins, burlap, or straw, and keeping wet as required.

8–8. Fine Grading

Labor for fine grading includes bringing in fill or removing excess earth, spreading, leveling, compacting, and sprinkling when necessary.

8–9. Vapor Barrier

Labor for placing vapor barrier includes handling into place, cutting to fit, smoothing as necessary, and sealing joints.

8–10. Expansion Joints

Labor for placing premolded expansion joints includes handling into place, cutting to fit, placing, and fastening to hold in position until concrete is placed. Labor for placing poured expansion joints includes cleaning joint of foreign matter, handling material to melting pot, melting, handling to joint, pouring joint, and dusting.

8–11. Cold Weather Protection

Several methods are available to provide cold-weather protection for concrete. These include covering the concrete with sand, straw, or paper; heating the aggregates and mixing water; and building inclosures and operating heaters.

8–12. Estimating Tables

Tables 8–1 through 8–8 are based on the use of untrained troops. The work rates are based on the crew sizes given in the tables and must be adjusted if crews of different makeup are employed. The tables do not include loading and hauling materials to the jobsite.

Table 8–1. Concrete Mixing and Placing

Work element description	Unit	Man-hours/unit
Hand mix:		
1 Mix board[1]	cy	5.0
16S Mixer:		
Charging with wheelbarrows		
Large crew[2]	cy	1.7
Small crew[3]	cy	2.0
Placing:[4]		
Placing directly into forms	cy	.4
Using wheelbarrows	cy	1.5
Using concrete buggies	cy	1.25

[1] Crew: 9–10 men.
[2] Crew: 14 men: 1 operator, 7 men with wheelbarrows loading gravel, 4 men with wheelbarrows loading sand, 2 men on cement.
[3] Crew: 8 men: 1 operator, 4 men with wheelbarrows loading gravel, 2 men with wheelbarrows loading sand, 1 man on cement.
[4] Crew: 9 men: 1 leader, 6 men wheeling concrete, 2 men dumping and screeding.

Table 8–2. Concrete Footings and Foundations

Work element description	Unit	Man-hours/unit
Formwork:[1]		
Column footings (assume 5′ x 5′ x 1 ½′)	100 SFCS	13.5
Wall footings (assume 1 foot deep)	100 SFCS	10.0
Footing keys (assume 2″ x 4″)	100 lf	3.2
Reinforcing:		
Loose in footings and piers	ton	16.0
Wired in place (vertical and horizontal)	ton	25.0
Mesh or fabric reinforced	100 sf	.5

[1] Crew: 2 carpenters, 1 helper.

Table 8–3. Concrete Slabs on Grade

Work element description	Unit	Man-hours/unit
Fine grade[1]	100 sf	1.2
Formwork – edge form[2]	100 lf	8.5
Screeds[1]	100 lf	1.25
Strip forms ≤ 12-inch[1]	100 lf	1.75
Reinforcing[1]		
Bend bars ≤ No. 8	1 ton	10
Bend bars > No. 8	1 ton	5
Place bars < No. 6	1 ton	15
Place bars ≥ No. 6	1 ton	12
Wire mesh	100 sf	2
Finish[1]		
Trowel (includes float)	100 sf	2.5
Float	100 sf	2.0

[1] Crew: 1 man.
[2] Crew: 2 carpenters, 1 helper.

Table 8–4. Concrete Structural Slabs

Work element description	Unit	Man-hours/unit
Formwork:		
Flat slab including shoring[1]	100 SFCA	12
Beam bottom, beam sides[1]	100 SFCA	20
Edge form ≤ 12 inches[1]	100 lf	9.5
Strip forms[2]	100 sf	2.0
Reinforcing[2]		
Same as table 8–3 but hoisting of materials to slab level must be added.		
Finish:		
Same as table 8–3		
Carborundun stone rub underside	100 sf	3.2
Placing:		
Rate of placing will depend on the method of hoisting the concrete.		

[1]Crew: 2 carpenters, 1 helper.
[2]Crew: 1 man.

Table 8–5. Concrete Walls

Work element description	Wall height (ft)	Unit	Man-hours/unit
Formwork:[1]			
Panel wall forms			
Making only	4–8	100 sf	5.8
Erect and remove	3–4	100 sf	9.0
Erect and remove	5–8	100 sf	13.5
Foundation wall forms	4–8	100 sf	13.5
Foundation wall forms	9–12	100 sf	18.0
Foundation wall forms	13–20	100 sf	23.0
Built in place forms	4–8	100 sf	14.5
Built in place forms	9–12	100 sf	19.0
Built in place forms	13–20	100 sf	24.0
Reinforcing:			
Set bars		ton	24.7
Set bars and tie in place		ton	27.5
Cure and cleanup		1,000 sf	1.0
Finish (carborundum stone)		100 sf	2.8
Patch tie holes[2]		100 sf	1.2

[1]Crew: 2 carpenters, 1 helper.
[2]Crew: 1 finisher, 1 laborer.

Table 8–6. Concrete Columns and Beams

Work element description	Unit	Man-hours/unit
Formwork:[1]		
Column forms (e.g. plywood sheathing)	100 SFCS	20.5
Inside beam and girder forms with shoring	100 SFCS	21.5
Spandrel beam or lintel forms with shoring	100 SFCS	26.7
Reinforcing:		
Set bars	ton	26.5
Set bars and tie in place	ton	29.5
Finish (carborundum stone)	100 sf	2.8
Cure and cleanup	100 sf	.10
Patch tie holes[2]	100 sf	1.2

[1] Crew: 2 carpenters, 1 helper.
[2] Crew: 1 finisher, 1 laborer.

Table 8–7. Cast-In-Place Concrete Culverts

Work element description	Unit	Man-hours/unit
Formwork:[1]		
Plywood sheathing, etc.	100 SFCS	26.7
Place reinforcing:		
Set bars and tie in place	ton	31.5
Mix and place concrete[2] (16S mixer)	cy	2.7
Place ready-mix concrete[3]	cy	2.2
Finish	1,000 sf	36.0
Cure and cleanup	1,000 sf	1.0
Finish (carborundum stone)	1,000 sf	32.0

[1] Crew: 2 carpenters, 1 helper.
[2] See table 8–1 for crew.
[3] Typical crew: 1 crew leader, 4 men erect/strip forms, 3 men placing reinforcing, 6–8 men placing, spreading, and vibrating concrete, 2–3 men finishing, 1–2 men cleanup.

Table 8–8. Cast-In-Place Concrete Transformer Vaults, Manholes, Catch Basins, and Valve Boxes––Install Precast Catch Basins, Valve Boxes and Manholes

Work element description	Unit	Man-hours/unit
Cast-in-place units:		
Formwork[1]		
Plywood sheathing, etc.	100 sfca	26.7
Reinforce:		
Set bars and tie in place	ton	31.5
Place manhole frame and cover	each	3.0
Place catch basin grate	each	2.0
Mix and place concrete[2] (16S mixer)	cy	3.2
Place ready-mix concrete[3]	cy	2.7
Finish	100 sf	3.6
Cure and cleanup	each	1.0
Overall:		
For all sizes of all units	cy	15.0
Precast units:		
See table 6–4 for amount of labor per various sized units.		

[1] Crew: 2 carpenters, 1 helper.
[2] Mix crew: 5 men on materials feeding mixer, 1 man dumping concrete into buggies.
[3] Placing crew: 1 crew leader, 3–5 men setting and removing forms, 4–7 men reinforcing, 3–5 men placing concrete.

CHAPTER 9

CARPENTRY

9–1. General

This chapter includes rough carpentry work and installation of flooring, finish carpentry, windows, doors, and insulation.

9–2. Rough Carpentry

Rough carpentry includes the work of measuring, cutting, and installing wood framing, including floor joists and sills, cross bridging, wall framing and plates, roof framing and rafters, and rough door bucks. It also includes all work in connection with installing wall and roof sheathing and siding.

9–3. Flooring

Flooring includes the work of measuring, cutting, and installing subflooring, finish flooring, and soft tile (asphalt, cork, rubber, and vinyl). It also includes the installation of building paper under finish floors and of adhesive under tile floors. In addition it includes building paper under soft tile when laid over wood floors.

9–4. Finish Carpentry

Finish carpentry includes the work of installing baseboard, molding, door and window frames and trim, kitchen cabinets, wooden stairs, closet units, and finish walls. This work also includes the installation of fastening devices such as plugs, expansion shields, and toggle bolts, also blocking for leveling and plumbing, as well as scribing fillers and trim to walls and adjacent pieces.

9–5. Windows and Doors

The tables in this chapter include the installation of double-hung and casement windows, jalousies, skylights, wood doors of all types, louvers, screens, venetian blinds, calking, and weather-stripping. Installation includes drilling for fasteners, installing plugs, expansion shields, toggle bolts, blocking, hinges, locks, and other hardware.

9–6. Insulation

The installation of insulation includes scaffolding when required, fastening insulation into place, and cutouts in insulation as required.

9–7. Estimating Tables

Tables 9–1 through 9–7 may be used to prepare detailed manpower estimates for carpentry. **Tables do not include provision for loading and hauling materials to the job.** All tables presume average working conditions in terms of weather, skill, motivation, crew size, accessibility, and the availability of equipment noted in TO&E 5-118 G.

9–8. Example of Table Use

a. Problem. A 24-foot by 40-foot frame storage shed is to be built as a part of a training program. Its interior partitions will be covered both sides with plasterboard, ceiling joists will be covered with plasterboard, and exterior walls will be covered with 4 x 8 treated fiberboard and 1 x 8 shiplap siding. There will be four interior doors, four exterior doors, and eight double-hung windows, all with plain trim. The estimates show the following quantities:

Floor joists and sills	1300 BF
Wall framing and plates	2120 BF
Ceiling joists	785 BF
Cross bridging	288 pr
Roof framing and rafters	2089 BF
Sheathing 4 x 8 fiberboard	1280 SF
Roof sheathing 1 x 8	1410 SF
Siding 1 x 8 shiplap	1280 SF
Subflooring 4 x 8 plywood	960 SF
Finish flooring softwood	960 SF
Door frame and trim	8 each
Window frame and trim	8 each
Finish walls – plasterboard	2240 SF
Windows – double hung	8 each
Doors – single interior	4 each
Doors – single exterior	4 each

Determine the man-hours needed for this project.

b. Solution. Using tables 9–1 through 9–7, the following computations are made:

Floor joists and sills 1.300 Mfbm x 32 m-h	=	41.6
Wall framing and plates 2.120 Mfbm x 56 m-h	=	118.7
Ceiling joists .785 Mfbm x 32 m-h	=	25.1
Cross bridging 2.88 hundred pr x 5 m-h	=	14.4
Roof framing and rafters 2.089 Mfbm x 48 m-h	=	100.3
Sheathing –4 x 8 fiberboard 1.280 thousand SF x 24 m-h	=	30.7
Roof sheathing –1 x 8 1.410 thousand SF x 24 m-h	=	33.8
Siding – 1 x 8 1.280 thousand SF x 48 m-h	=	61.4
Subflooring – 4 x 8 plywood .96 thousand SF x 16 m-h	=	15.4
Finish flooring – softwood .960 thousand SF x 24 m-h	=	23.0
Door frame and trim 8 x 2.5 m-h	=	20
Window frame and trim 8 x 3 m-h	=	24
Finish walls – plasterboard 2.240 thousand SF x 48 m-h	=	107.5
Windows – double hung 8 x 2.5 m-h	=	20
Doors – single interior 4 x 1.5 m-h	=	6
Doors – single exterior 4 x 2 m-h	=	8
Total man-hours required	=	649.9

Use 650 man-hours

Table 9–1. Rough Framing [1]

Work element description	Unit	Man-hours/unit	
Beams (3–2" x 8")	Mfbm[2]	40	
Floor joists, sills	Mfbm	32	
Bridging	100 pairs	5	
Wall frames, plates	Mfbm	56	
Furring, include plugging	1,000 linear feet	32	
Blocking	Mfbm	32	
Grounds for plaster	1,000 linear feet	48	
Door bucks	Each	3	
Ceiling joists	Mfbm	32	
Rafters	Mfbm	48	
		Man-hours assembly	Man-hours placement
Trusses	Each		
Span feet			
20		2.5	4
30		5	8
40		12	8
50		20	6[3]
60		24	6[3]
80		32	6[3]

[1] Typical crew: 1 leader, 8 men. Minimal crew: 1 leader, 2 men.
[2] Thousand board foot measure.
[3] Assumes use of organizational crane, 1 operator, 1 oiler, 2 or 3 men on guylines.

Table 9–2. Sheathing and Siding[1]

Work element description	Unit	Man-hours/unit
Wall sheathing	1,000 square feet	
Building paper		16
Tongue and groove		24
Plywood		16
Fiberboard		24
Roof decking	1,000 square feet	
Tongue and groove		32
Plywood		24
Siding	1,000 square feet	
Plywood		24
Corrugated asbestos		32
Drop siding		32
Narrow bevel		48
Shingles		40

[1] Typical crew: 1 leader, 8 men.

Table 9–3. Flooring[1]

Work element description	Unit	Man-hours/unit
Wood floors	1,000 square feet	
Subfloor		
Tongue and groove		24
Plywood		16
Finish floor		
Softwood		24
Hardwood		32
Soft tile	1,000 square feet	
Cemented		24
Nailed		32
Linoleum	1,000 square feet	32

[1] Typical crew: 1 leader, 4 men.

Table 9–4. Insulation[1]

Work element description	Unit	Man-hours/unit
Thermal	1,000 square feet	
Board		
Floor		8
Wall		32
Ceiling		24
Roof		16
Rock wool		
Loose		16
Batts		24
Foil alone		16
Rigid foam		32
Acoustic	1,000 square feet	
Strip		24
Quilt		8

[1] Typical crew: 1 leader, 4 men.

Table 9–5. Finish Carpentry[1]

Work element description	Unit	Man-hours/unit
Walls	1,000 square feet	
Plywood		32
Plasterboard (includes tape)		48
Ceilings	1,000 square feet	
Wood		48
Plasterboard (includes tape[2])		64
Cemented tile		32
Panel with suspension		72
Baseboard (2 member)	1,000 linear feet	72
Molding (chair)	1,000 linear feet	48
Door frame, trim	Each	2.5
Sliding door with pocket	Each	8
Window frame, trim	Each	3
Installing prefab closets	Each	16
Setting kitchen cabinets	Each	1.5
Shelving	1,000 square feet	64
Chalkboard (complete)	1,000 square feet	110
Stairs		
Closed stringer, built on job	Story	16
Closed stringer, prefab	Story	8
Open stringer	Story	24

[1] Typical crew: 1 leader, 3–8 men.
[2] Includes installation of furring strips when necessary.

NOTE: For small rooms increase time required for wall and ceiling board installation by 30 to 50 percent.

Table 9–6. Wood Door Installation [1]

Work element description	Unit	Man-hours/unit
Doors with hardware	Each	
Exterior[2]		2
Interior[2]		1.5
Manual sliding (includes tracks)		8
Motorized sliding[3]		56
Overhead (includes machinery)		16
Screendoors		1.5
Calking (with gun)	1,000 linear feet	16
Weatherstripping	Each opening	1.5

[1] Typical crew: 1 leader, 4 men.
[2] For double doors add 50 percent to labor estimates.
[3] Includes tracks and all necessary machinery, with control equipment.

Table 9–7. Wood Window Installation [1]

Work element description	Unit	Man-hours/unit
Windows (average 20 square feet)	Each	
Double-hung		2.5
Casement		1.5
Sliding		2.5
Jalousie		2.5
Louvers		4
Skylight		8
Screens	Each	1.5
Venetian blinds	Each	1
Calking (with gun)	1,000 linear feet	16
Weatherstripping	Each opening	1.5

[1] Typical crew: 1 leader, 4 men.

CHAPTER 10

MASONRY

10–1. Scope

Masonry includes the installation of brick, concrete block, mortar-bound rubble, ceramic tile, quarry tile, structural tile (glazed or face), lathing, and plastering.

10–2. Brick and Concrete Block

Labor required for the installation of brick and concrete block includes mixing mortar, carrying materials to mason, hoisting materials, laying brick and block, tooling joints, erecting and dismantling scaffold, sawing block, culling brick and block, and cleaning brick and block in place.

10–3. Mortar-Bound Rubble

Labor required for the installation of mortar-bound rubble includes mixing mortar, rough cutting stone, carrying mortar and rubble to mason, hoisting materials, laying rubble, tooling and pointing joints, erecting and dismantling scaffold, and cleaning rubble in place.

10–4. Ceramic and Quarry Tile

Labor required for the installation of ceramic and quarry tile includes mixing mortar for bed coat and joints, carrying mortar and tile to tilesetter, spreading bed coat, cutting tile, setting tile, slushing and finishing joints, cleaning tile in place, and erecting and dismantling scaffold.

10–5. Structural Tile

Labor required for the installation of structural face tile and glazed structural tile units includes mixing mortar, carrying mortar and tile to mason, hoisting materials, laying tile, tooling joints, erecting and dismantling scaffold, cutting tile, and cleaning tile in place.

10–6. Lathing and Plastering

Labor required for lathing and plastering includes handling material into place, hoisting materials, cutting and installing hanging wires and straps; cutting and fastening lathing channels, angles, beads, and moldings; installing furring strips, metal lath, and gypsum lath; mixing plaster; installing and finishing plaster; erecting and dismantling scaffold; and curing and drying plaster.

10–7. Estimating Tables

Unit masonry tables 10–1 through 10–3 include mixing mortar, carrying materials, culling, cutting, hoisting, laying masonry, tooling joints, and cleaning work in place. For lathing (table 10–4), labor includes installing required metal fastenings and furring. Estimates for plastering (table 10–5) include mixing, hoisting, finishing, and curing. Allowances are made for erecting and dismantling scaffolds in all cases. **Estimates do not include provision for loading and hauling material to the job site.**

10–8. Example of Table Use

a. Twenty housing units are to be built in Germany when weather is generally favorable to construction. Estimate the number of working days it will take to complete the project. Material estimates are as follows:

8-inch concrete block	20,000 square feet
(Acid cleaning block	20,000 square feet)
6-inch quarry tile	1,000 square feet
Tile base (6-inch)	500 linear feet
(Acid cleaning tile	1,250 square feet)
Glass block	1,000 square feet
Metal lath – walls (metal studs)	25,000 square feet
Metal lath – ceiling (wood joists)	10,000 square feet
Metal lath – base	2,500 linear feet
Corner bead	2,500 linear feet
Lath at openings	4,000 linear feet
Plastering walls (2 coats)	25,000 square feet
Plastering ceilings (plain finish)	10,000 square feet
Scaffolding	1 story – 8 crews

b. Labor is mostly inexperienced, so man-hours/unit are figured at 30 percent above tables:

	Units	x	Man-hours/unit	=	Subtotal
Laying block	20		143		2,860
Cleaning block	20		33		660
Laying tile:					
Floor	1		208		208
Base	.5		299		150
Cleaning tile	1.25		13		16
Glass block	1		325		325
Metal lath:					
Walls	25		52		1,300
Ceiling	10		13		130
Base	2.5		46		115
Corner	2.5		46		115
Openings	4		91		364
Plastering:					
Walls	25		31		775
Ceilings	10		55		550
Scaffold	8		26		208
				Total	7,776 man-hours

c. Assuming an 8-hour workday, work requires 972 man-days. An engineer company consisting of 90 laborers, using organic equipment, could complete the project in

$$\frac{972}{90} = 10.8 \text{ or } 11 \text{ working days.}$$

Table 10–1. Brick, Concrete Block, Mortar-Bound Rubble[1]

Work element description	Unit	Man-hours/unit
Common brick	1,000 square feet	
8" wall		150
12" wall		200
16" wall		300
Acid cleaning brick	1,000 square feet	20
Concrete block	1,000 square feet	
4" wall		80
8" wall		110
12" wall		150
Acid cleaning block	1,000 square feet	25
Mortar-bound rubble, complete	Cubic yard	30
Erect and dismantle tubular scaffold	Story - 1 crew	20

[1] Typical crew: 1 leader, 6 men for masonry; 1 leader, 3 men for scaffolding.

Table 10–2. Structural Tile[1]

Work element description	Unit	Man-hours/unit
Backup tile	1,000 square feet	
4" wall		110
8" wall		120
12" wall		140
Glazed tile	1,000 square feet	
4" wall		300
8" wall		320
Glass and terra cotta block, complete	1,000 square feet	250
Acid cleaning tile	1,000 square feet	10

[1] Typical crew: 1 leader, 6 men.

Table 10–3. Ceramic and Quarry Tile [1]

Work element description	Unit	Man-hours/unit
Floors	1,000 square feet	
Ceramic		
Paper-backed		160
Unmounted		240
Quarry		
4-inch square		200
6-inch square		160
9-inch square		80
Walls (includes preparation of surface)	1,000 square feet	250
Base	1,000 linear feet	230
Cap	1,000 linear feet	190

[1] Typical crew: 1 leader, 3 men.

Table 10–4. Lathing[1]

Work element description	Unit	Man-hours/unit
Walls	1,000 square feet	
Wood lath		10
Metal lath		10
Wood studs, 2-inch solid partition		35
Metal studs, 2 sides		40
Ceiling	1,000 square feet	
Wood joists		10
Suspended		30
Base	1,000 linear feet	
Wood		30
Metal		35
Corner bead	1,000 linear feet	35
Moldings at openings	1,000 linear feet	70

[1] Typical crew: 1 leader, 3 men.

Table 10–5. Plastering[1]

Work element description	Unit	Man-hours/unit
Interior walls	1,000 square feet	
2 coats		24
3 coats		35
2" solid partition		80
Metal studs, 2 sides		40
Ceiling (3 coats)	1,000 square feet	42[2]
Exterior, stucco	1,000 square feet	45

[1] Typical crew: 1 leader, 6 men.
[2] Add 8 man-hours/unit for sand finish.

CHAPTER 11

ROOFING

11–1. Scope

Roofing includes the following types: built-up, roll, shingle, metal, asbestos-cement, and tile. Tables 11–1 through 11–4 include allowances for unloading and storing materials at the construction site, and hoisting.

11–2. Built-Up Roofing

Table 11–1 includes melting asphalt, laying felt, mopping, and laying gravel.

11–3. Roll Roofing

Table 11–2 includes cleaning deck, applying prime coat, and laying rolls.

11–4. Shingle Roofing

Table 11–3 includes placing and nailing.

11–5. Metal, Asbestos-Cement, and Tile Roofing

Table 11–4 includes placing, calking, drilling, and fastening materials.

11–6. Estimating Tables

Tables 11–1 through 11–4 may be used in preparing detailed manpower estimates for roofing. They do not include provision for loading and hauling materials to the job site.

11–7. Example of Table Use

a. A warehouse is to be built in Southeast Asia. Heavy rains require a 4-ply built-up roof to be applied during the dry season. Estimate the number of man-hours needed to build the roof.

b. The material estimate is as follows:

4-ply built-up roof	5,000 square feet
Roof insulation	5,000 square feet
Flashing	300 linear feet

c. Because crews are inexperienced, man-hours/unit are increased 30 percent over figures given in table 11–1:

	Units	Man-hours/unit	Subtotal
4-ply built-up roof	5	33	165
Insulation	5	33	165
Flashing	0.3	78	23
Total man-hours			353

Table 11–1. Built-Up Roofing, Insulation, and Flashing[1]
(pitch 1/2 inch to 3 inches/foot)

Work element description	Unit	Man-hours/unit
Roofing	1,000 square feet	
2 ply	----------	12
3 ply	----------	20
4 ply	----------	25
5 ply	----------	30
Insulation	1,000 square feet	25
Flashing	1,000 linear feet	60

[1] Typical crew: 1 leader, 6 men.

Table 11–2. Roll Roofing[1]
(pitch at least 2 inches/foot)

Work element description	Unit	Man-hours/unit
Paper (plain) and felt	1,000 square feet	7
Asphaltic aluminum (including primer)	1,000 square feet	18
Canvas (including 2 coats paint)	1,000 square feet	25

[1] Typical crew: 1 leader, 6 men.

Table 11–3. Shingle Roofing[1]
(pitch at least 3 inches/foot)

Work element description	Unit	Man-hours/unit
Wood	1,000 square feet	35
Slate	1,000 square feet	55
Metal	1,000 square feet	50
Asbestos	1,000 square feet	45
Asphalt	1,000 square feet	30

[1] Tynical crew: 1 leader, 4 men.

Table 11–4. Metal, Asbestos-Cement, and Tile Roofing[1]
(pitch at least 3 inches/foot)

Work element description	Unit	Man-hours/unit
Metal	1,000 square feet	
Corrugated and V-crimp		
Wood purlins		18
Metal purlins		36
Sheet (seamed)		60
Asbestos-cement	1,000 square feet	
Wood purlins		35
Metal purlins		45
Tile	1,000 square feet	
Clay		55
Metal		60

[1] Typical crew: 1 leader, 5 men.

CHAPTER 12

ELECTRICAL WORK

12–1. General

Electrical work includes construction of electrical distribution lines, outdoor lighting, and underground power systems; installation of interior electrical services, transformers, and substation equipment.

12–2. Electrical Line Work

Electrical line work includes the work of unloading materials, excavating, installing crossarms and insulators, setting poles, backfilling, stringing and sagging wire. It also includes installing and connecting transformers, switches, breakers, capacitors, and regulators.

12–3. Outdoor Lighting

Outdoor lighting includes street and security lighting, airfield lighting, and athletic field lighting. The work of installing this lighting includes excavating foundations, setting poles, backfilling, installing standards, installing light fixtures, stringing wire, laying burial cable, installing duct, incasing duct in concrete, pulling cable, installing control devices, lamps, control vaults, and transformers.

12–4. Underground Power System

The construction of an underground power system includes excavating, installing ducts, incasing ducts with concrete, backfilling, compacting, pulling cable, constructing transformer vaults, installing transformers, and constructing manholes and handholes.

12–5. Interior Electrical Rough-In

Electrical rough-in includes installing service mains, switches, panels, conduits, fittings, outlet boxes, nonmetallic cable, armored cable, transformers, and motor control centers. It also includes the pulling of cable in conduit and splicing in electrical boxes.

12–6. Interior Electrical Finish and Trim

Electrical finish and trim includes installing and connecting receptacles, switches, light fixtures, light duty devices, heavy duty utility devices, controls, and appliances. It also includes circuit testing.

12–7. Transformers and Substation Equipment

Installation of transformers and substation equipment includes unloading, moving into position, leveling, plumbing, fastening, trimming, and connecting.

12–8. Estimating Tables

Tables 12–1 through 12–9 may be used in preparing detailed manpower estimates for electrical construction. **The tables do not include provision for loading and hauling equipment and materials to the jobsite.** These tables are given for average working conditions. To adjust these to a particular situation, the weather condition, skill and experience of the men, time allotted for completion, size of crew, types of material used, and types of equipment should be considered.

12–9. Example of Table Use

To make a manpower estimate for electrical work using the tables in this chapter, follow the procedure in the example below.

a. Interior electrical work is to be performed in a two-family housing unit. The work element estimate shows the following quantities of work to be performed:

Electrical service main, 100 amp	1 each
Electric panels, 8-circuit	2 each
Conduit and boxes, 1 ¼ inches and smaller	1100 lf
Pull and splice wire, No. 10 and smaller	2200 lf
Pull and splice wire, No. 8 and larger	160 lf
Receptacles and switches	30 each

Incandescent fixtures .....14 each
Attic exhaust fans .....2 each
Hot water heater .....2 each

b. The project is located in an area of moderate rainfall. Most of the work crew are experienced men, so the estimator decides to subtract 15 percent from the man-hour estimates. Referring to tables 12–5 and 12–6, the man-hours per unit to be used are computed as follows:

Electric service main, 100 amp
14.4 (.85) = 12.2 mh/each

Electric panels, 8-circuit
14.4 (.85) = 12.2 mh/each

Conduit and boxes, 1 ¼ inches and smaller
320.0 (.85) = 272.0 mh/1000 lf

Pull and splice wire, No. 10 and smaller
24.0 (.85) = 20.4 mh/1000 lf

Pull and splice wire, No. 8 and larger
56.0 (.85) = 47.5 mh/1000 lf

Receptacles and switches
1.1 (.85) = 0.93 mh/each

Incandescent fixtures
1.6 (.85) = 1.36 mh/each

Attic exhaust fans
14.4 (.85) = 12.2 mh/each

Hot water heater
8.0 (.85) = 6.7 mh/each

c. Man-hours required for electrical work are computed using the above units.

Rough-in:

Service main: 1 each x 12.2 mh/each	= 12.2 mh
Panels: 2 each x 12.2 mh/each	= 24.4 mh
Conduit: 1.1 x 1000 lf x 272 mh/1000 lf	= 299.2 mh
Wire, No. 10: 2.2 x 1000 lf x 20.4 mh/1000 lf	= 44.9 mh
Wire, No. 8: .16 x 1000 lf x 47.5 mh/1000 lf	= 7.6 mh
Total man-hours for rough-in	= 388.3 mh

Finish and Trim:

Receptacles and switches: 30 each x .93 mh/each	= 27.9 mh
Fixtures: 14 each x 1.36 mh/each	= 19.0 mh
Fans: 2 each x 12.2 mh/each	= 24.4 mh
Hot water heater: 2 each x 6.7 mh/each	= 13.4 mh
Total man-hours for finish and trim	= 84.7 mh

Total electrical work in one two-family housing unit: 388.3 + 84.7 = 473.0 man-hours.

Table 12–1. Electrical Line Work

Work element description	Unit	Man-hours/unit
Set poles, including guying, hardware and grounding:		
Line poles	each	32.0
Corner poles	each	80.0
H-pole and transformer platform	each	96.0
String wire including connections:		
No. 6 to No. 1 wire	1,000 lf	40.0
No. 1/0 to No. 4/0 wire	1,000 lf	96.0
Set pole-mounted transformers:		
50 kva 1ϕ	each	32.0
25 to 37.5 kva 1ϕ	each	24.0
5 to 15 kva 1ϕ	each	16.0
Pole top air break switches	each	96.0
Disconnect switches	each	8.0
Guying and tying	1,000 lf	448.0
Capacitors:		
Single phase (1ϕ)	each	12.0
Three phase (3ϕ)	each	32.0
Regulators:		
12.5 to 25 kva 1ϕ pole-mounted	each	32.0
12.5 to 37.5 kva 3ϕ platform mounted	each	64.0
50 to 75 kva 3ϕ platform mounted	each	112.0
100 to 125 kva 3ϕ platform mounted	each	176.0
For quick estimates:		
Line work complete	1,000 lf	400.0

Typical crew: 1 crew leader, 4 linemen, 2 splicers, 2 ground men, 1 truckdriver, and 1 crane operator.

Equipment: Compressor, pneumatic air-tamper, crane, truck, tractor with a winch drum and cable, stringing blocks and slings, bolt cutters, grips, chains, cable, and rope.

Not included in these estimates are man-hours required for hole-digging.

Table 12–2. Street, Security, and Athletic Field Lighting

Work element description	Unit	Man-hours/unit
Install foundations for light standards:		
Street lighting	each	19.2
Security lighting	each	19.2
Athletic field lighting	N/A[1]	N/A
Install lighting standards including wiring:		
Street lighting	each	16.0
Security lighting	each	16.0
Athletic field lighting	N/A	N/A
Setting poles:		
Street lighting	each	24.8
Security lighting	each	24.8
Athletic field lighting	each	32.0
Trench excavation for burial cable:		
Hand	1,000 lf	640.0
Machine	1,000 lf	40.0
Install fixtures, including wiring	each	12.0
Install direct burial cable including risers and splicing when applicable	1,000 lf	48.0
Install overhead cable, including splicing	1,000 lf	40.0
Install lighting transformer		
10 to 20 kva	each	16.0
25 to 30 kva	each	24.0
Install control devices	each	8.0
Install lamps	each	0.64
For quick estimates:		
Street lighting, complete	1,000 lf	256.0
Security lighting, complete	1,000 lf	360.0
Athletic field lighting, complete	luminaire	5.2

Typical crew: 1 crew leader, 2 men excavating, 4 men setting poles and installing fixtures, 1 truckdriver, and 1 crane operator.

Equipment: Crane, truck, compressor, pneumatic air-tamper, and ordinary handtools.

[1] Not applicable.

Table 12–3. Airfield Lighting

Work element description	Unit	Man-hours/unit
Install burial cable, including splicing	1,000 lf	48.0
Trenching for ducts or cable, including backfill and compaction:		
Hand	cy	8.8
Machine	1,000 cy	560.0
Install duct	1,000 lf	272.0
Incase duct in concrete	cy	3.2
Pull cable, including splicing	1,000 lf	64.0
Install lighting fixtures including wiring	each	12.0
Install control devices	each	8.0
Install control vaults	each	192.0
For quick estimates:		
Airfield lighting complete using machine excavation:		
Direct burial cable	1,000 lf	216.0
Duct system (2-way)	1,000 lf	976.0

Typical crew: 1 crew leader, 2 men trenching, 3 men placing concrete, 5 men pulling and splicing cable, 2 men installing fixtures and control devices, and 1 truckdriver.

Equipment: Ditcher, air compressor with tamper, backhoe, truck soldering outfits, fishing wire, and handlines.

Table 12–4. Underground Power System

Work element description	Unit	Man-hours/unit
Trenching for ducts, including backfill and compaction:		
Machine	1,000 cy	560.0
Hand	cy	8.8
Install ducts, including risers	1,000 lf	288.0
Incase ducts with concrete	cy	3.2
Pull cable, including splicing	1,000 lf	112.0
Install transformers:		
100 kva dry type	each	80.0
167 kva to 500 kva dry type	each	136.0
Transformer vaults	each	See table 8–8
Manholes and/or handholes	each	See table 8–8
For quick estimates: ducts complete, including machine excavation, backfill, and concrete incasement:		
2-way ducts	1,000 lf	792.0
4-way ducts	1,000 lf	1496.0
6-way ducts	1,000 lf	2208.0
9-way ducts	1,000 lf	3248.0
Underground power system, complete[1]	1,000 lf	2400.0

Typical crew: 1 crew leader, 2 men excavating, 3 men placing concrete, 5 men pulling and splicing, 1 truckdriver, and 4 to 8 men on transformer installation.

[1] Includes complete duct installation, pulling and splicing cable, manholes, handholes, transformer vaults, and transformers.

Table 12–5. Electrical Rough-In – Housing and Barracks

Work element description	Unit	Man-hours/unit
Electric service main:		
30 amp service	each	8.0
60 amp service	each	11.2
100 amp service	each	14.4
Electric panels:		
8 circuit	each	14.4
16 circuit	each	25.6
Install conduits, fittings, and outlet boxes:		
1 ¼ inches and smaller	1,000 lf	320.0
1 ½ inches and larger	1,000 lf	520.0
Pull and splice wire:		
No. 10 and smaller	1,000 lf	24.0
No. 8 and larger	1,000 lf	56.0
Install nonmetallic cable, fittings, and outlet boxes:		
No. 10 and smaller	1,000 lf	168.0
No. 8 and larger	1,000 lf	304.0
Install armored cable, fittings, and outlet boxes:		
No. 10 and smaller	1,000 lf	168.0
No. 8 and larger	1,000 lf	304.0

Typical crew: 1 crew leader, 3 men on conduit installation, and 4 men on wire pulling and splicing.

Equipment: Heavy rigid conduit work will require pipe cutters, hacksaws, threading tools, reamers, and other small tools needed for conduit work. Light rigid conduit work will not require threading tools. Other small tools needed will include hand and electric drills, saws, hammers, chisels, gasoline torches, soldering outfits, fishing wire, pliers, and handlines. Ladders, stepladders, sawhorses, and planks may be needed for scaffolding.

Note: 1. A predominance of small size conduit will create a more favorable condition than a big percentage of large size conduit in either conduit item.

2. A large number of short length circuits would tend to create unfavorable conditions and would increase the man-hours required to pull and splice each 1000 lineal feet of cable. Similarly a predominance of very short conduit runs would increase the number of man-hours required per 1000 lf.

Table 12–6. Electrical Finish and Trim – Housing and Barracks

Work element description	Unit	Man-hours/unit
Install receptacles and switches	each	1.1
Install incandescent fixtures	each	1.6
Install fluorescent fixtures	each	4.8
Install appliances:[1]		
Dryers, hot water heater, ranges	each	8.0
Small space heaters	each	4.0
AC units 1 ton and smaller	each	12.8
Exhaust fans	each	14.4
Circuit testing	circuit	1.6

Typical crew: 1 crew leader and 2 to 4 men.

Equipment: Ordinary handtools and ladder if needed.

[1] Based on standard size appliances.

Table 12–7. Electrical Rough-In – Industrial

Work element description	Unit	Man-hours/unit
Electric service main:		
60 amp service 3ϕ-4 wire	each	11.2
100 amp service 3ϕ-4 wire	each	14.4
200 amp service 3ϕ-4 wire	each	24.0
Electric panels:		
8 circuit	each	14.4
16 circuit	each	25.6
24 circuit	each	35.2
30 circuit	each	43.2
Install conduit, fittings and outlet boxes		
1 ¼ inches and smaller	1,000 lf	320.0
1 ½ inches and larger	1,000 lf	592.0
Install cable, including splicing:		
No. 10 and smaller	1,000 lf	24.0
No. 8 and larger	1,000 lf	72.0
Install nonmetallic cable, fittings, and outlet boxes:		
No. 10 and smaller	1,000 lf	32.0
No. 8 and larger	1,000 lf	56.0
Install metallic cable fittings and outlet boxes:		
No. 10 and smaller	1,000 lf	64.0
No. 8 and larger	1,000 lf	96.0
Transformers, floor-mounted:[1]		
1 to 3 kva	each	8.0
5 to 10 kva	each	17.6
15 to 25 kva	each	38.4
37.5 to 50 kva	each	76.8
Motor control centers (average section 24" x 96" x 14")[2]	per section	25.2

Typical crew: 1 crew leader, 2 to 3 men on panels, 3 to 5 men on conduit, 3 to 5 men on stringing cable and splicing, and 2 to 4 men on transformer installation.

Equipment: Heavy rigid conduit work will require pipe cutters, hacksaws, threading tools, etc. Light rigid conduit work will not require threading tools. See table 12–5.

[1] Add 20 percent for wall or column mounting.

[2] Includes setting and connecting.

Table 12–8. Electrical Finish and Trim – Industrial

Work element description	Unit	Man-hours/unit
Install receptacles and switches	each	1.1
Install incandescent light fixtures	each	1.6
Install fluorescent light fixtures	each	7.2
Hook up light duty devices including testing	each	13.6
Hook up heavy duty devices including testing, with controls	each	120.0
Circuit testing	circuit	1.6

Typical crew: 1 crew leader and 2 to 3 men.

Equipment: Ordinary handtools and ladder or scaffold if needed.

Table 12–9. Burglar and Fire Alarm Systems

Work element description	Unit	Man-hours/unit
Burglar alarm:		
Open and closed circuit springs	each	0.8
Contactors	each	1.8
Electric matting	each	1.8
Constant ringing drop	each	2.9
Relays	each	2.3
Fire alarm:		
Auto thermostat	each	1.6
Special outlet box	each	1.1
Bell	each	1.3
Horn or small motor-driven siren	each	2.1
Annunciator mounting	each	2.2
Annunciator connections	per terminal	0.4
Control panel	each	7.2
Transformers	each	7.2
Cable pulled in conduit	1,000 lf	11.2
Cable exposed	1,000 lf	19.2

Typical crew: 1 crew leader and 1 to 3 men.

Equipment: Ordinary handtools.

CHAPTER 13

PLUMBING

13–1. General

Plumbing includes the work of installing cast iron and steel pipe, valves and fittings, fire hydrants, thrust blocks, concrete pipe, vitrified clay pipe, asbestos-cement pipe, roughing-in plumbing, and installing fixtures.

13–2. Cast Iron and Steel Pipe

The installation of cast iron and steel pipe includes unloading, placing, joint make-up, and testing.

13–3. Valves and Fittings

The installation of valves and fittings includes unloading, placing, calking and leading, welding, and bolting flanges. It also includes installing gaskets, packing, hand wheels, and trim.

13–4. Fire Hydrants, Post Indicator Valves, and Thrust Blocks

The installation of fire hydrants and post indicator valves includes unloading, placing, calking, bolting, clamping, adjusting to grade, and plumbing stems. The installation of thrust blocks includes bracing, forming, reinforcing, placing concrete, and stripping forms.

13–5. Concrete and Vitrified Clay Pipe

The installation of concrete and vitrified clay pipe includes unloading, placing, calking, grouting, installing gaskets, and testing.

13–6. Asbestos–Cement Pipe

The installation of asbestos-cement pipe includes unloading, placing, installing gaskets, soaping, pulling sleeve over joint, and testing.

13–7. Rough-In Plumbing

The roughing-in of plumbing includes unloading and installing sewer and drain pipe, installing water pipe, and testing. The installation of cast iron drains includes calking and leading joints, plumbing and grading pipe, installing pipe hangers and straps, cutting pipe, and installing fittings. The installation of galvanized steel pipe vents and drains includes cutting and threading pipe, making joints including applying joint compound, plumbing and grading pipe, installing pipe hangers and straps, and installing fittings. The installation of copper and galvanized steel water pipe includes cutting, threading and making steel pipe joints, cleaning and soldering copper pipe joints, plumbing and grading pipe, and installing pipe hangers and straps.

13–8. Finish Plumbing

The installation of finish plumbing includes setting and connecting all plumbing fixtures (such as bathtubs, lavatories, water closets, urinals, showers, and sinks).

13–9. Estimating Tables

Tables 13–1 through 13–6 may be used in preparing detailed manpower estimates for plumbing installations. **The tables do not include provision for loading and hauling equipment and materials to the jobsite.**

13–10. Example of Table Use

Twenty housing units are to be constructed. Estimate the number of man-hours needed for rough-in. The following quantities are obtained from the activity estimates:

Rough-in sanitary lines 4" cast iron and smaller	145 joints
Rough-in water lines 3/4" and smaller threaded pipe	185 joints
Rough-in fixtures	
Bathtub with shower	20 each
Lavatory	20 each
Water closet	20 each
Kitchen sink	20 each

Solution: Using tables 13–1 through 13–6, the following computations are made:

4" and smaller cast iron drain line 145 joints x .85 m-h	=	123
3/4" and smaller water line 185 joints x 1.00 m-h	=	185
Rough-in fixtures:	=	
Bathtub with shower 20 each x 19 m-h	=	380
Lavatory 20 each x 14 m-h	=	280
Water closet 20 each x 16 m-h	=	320
Kitchen sink 20 each x 12 m-h	=	240
Total man-hours for rough-in	=	1528

Use 1530 man-hours

Table 13–1. Installation of Pipe –– Welded Steel Pipe Lines

Work element description	Unit	Man-hours/unit
Install schedule 40 pipe, by oxyacetylene welding, butt weld; positions include horizontal, vertical, and overhead		
1 inch	joint	.9
1 ¼ inches	joint	1.02
1 ½ inches	joint	1.12
2 inches	joint	1.15
2 ½ inches	joint	1.43
3 inches	joint	1.67
3 ½ inches	joint	1.87
4 inches	joint	2.13
5 inches	joint	2.74
6 inches	joint	3.73
8 inches	joint	4.91
10 inches	joint	6.72
Install schedule 40 pipe, by metallic arc welding, butt welds; positions include horizontal, vertical, and overhead		
1 inch	joint	.9
1 ¼ inches	joint	1.1
1 ½ inches	joint	1.15
2 inches	joint	1.39
2 ½ inches	joint	1.76
3 inches	joint	2.07
3 ½ inches	joint	2.30
4 inches	joint	2.65
5 inches	joint	3.34
6 inches	joint	4.33
8 inches	joint	5.9
10 inches	joint	8.12

The time for installation of the pipe includes erecting and alining pipe in hangers, cutting and beveling one end of pipe, and welding pipe.

Schedule 40 steel pipe corresponds to former designation: "standard". Schedule 80 steel pipe corresponds to former designation: "extra strong". Schedule number is selected using formula: Schedule No. = 1000 x P/S, where P is operating pressure, psig and S is allowable stress value, psi.

For schedule 80 pipe multiply man-hours by 1.6.

This table is based upon a crew of 3 men: 1 pipefitter, 1 welder, and 1 helper.

Table 13–2. Installation of Thrust Blocks, Valves, and Fittings – Welded Steel Pipe Lines

Work element description	Unit	Man-hours/unit
Install thrust blocks for (2-man crew)		
12-inch and smaller pipe	each	6.4
14- to 24-inch pipe	each	9.6
Install[1] standard (welded) fittings, butt welded, oxyacetylene and arc, all positions		
1 inch	each	.45
1 ¼ inches	each	.65
1 ½ inches	each	.7
2 inches	each	.88
2 ½ inches	each	1.14
3 inches	each	1.36
3 ½ inches	each	1.48
4 inches	each	1.62
5 inches	each	2.06
6 inches	each	2.64
8 inches	each	3.56
10 inches	each	5.11
Install[2] standard valves, oxyacetylene and metallic arc		
1 inch	each	.5
1 ¼ inches	each	.95
1 ½ inches	each	1.05
2 inches	each	1.15
2 ½ inches	each	1.38
3 inches	each	1.62
3 ½ inches	each	1.86
4 inches	each	2.06
5 inches	each	2.62
6 inches	each	3.58
8 inches	each	5.06
10 inches	each	7.8

[1] This is based on the average time required to erect, aline, and weld-up the fittings. The crew consists of two men: 1 welder and 1 helper.

For extra-heavy fittings multiply by a factor of 1.3.

[2] This is based on the average time it takes for a crew of 2 men (welder and helper) to erect and aline, and weld-out the fittings on the valve.

For extra-heavy fittings, multiply by a factor of 1.5.

Table 13–3. Installation of Steel Pipe, Threaded and Flanged (Schedule 40)

Work element description	Unit	Man-hours/unit
Install threaded pipe, schedule 40		
1/2 – 3/4 inch	joint	1.00
1 inch	joint	1.16
1 ¼ inches	joint	1.24
1 ½ inches	joint	1.36
2 inches	joint	1.6
2 ½ inches	joint	2.00
3 inches	joint	2.4
3 ½ inches	joint	2.8
4 inches	joint	3.2
5 inches	joint	4.4
6 inches	joint	5.6
8 inches	joint	7.6
Install schedule 40 pipe, flange fittings		
2 inches	joint	1.08
2 ½ inches	joint	1.3
3 inches	joint	1.4
3 ½ inches	joint	1.5
4 inches	joint	2.12
5 inches	joint	2.7
6 inches	joint	3.3
8 inches	joint	4.5
10 inches	joint	7.00
12 inches	joint	8.2
Install thrust block		
12 inches and smaller	each	6.4
14 inches and larger	each	9.6
Install flanged fittings (schedule 40)		
2 inches	each	.8
2 ½ inches	each	.88
3 inches	each	.96
3 ½ inches	each	1.06
4 inches	each	1.6
5 inches	each	1.94
6 inches	each	2.2
8 inches	each	2.68
10 inches	each	2.72
12 inches	each	5.8

Table 13–3. Installation of Steel Pipe, Threaded and Flanged (Schedule 40) – Continued

Work element description	Unit	Man-hours/unit
Install threaded and flanged valves (schedule 40)		
2 inches	each	.6
2 ½ inches	each	.72
3 inches	each	.82
3 ½ inches	each	1.00
4 inches	each	1.1
5 inches	each	1.4
6 inches	each	1.9
8 inches	each	3.1
10 inches	each	5.00
12 inches	each	8.00

This table is based on the fabrication and installation of pipe per joint. The job operations taken into account are making fittings service tight, installing, handling materials and tools, and threading one end per joint.

Crew size in table is based on 1 pipefitter and 1 helper for pipe under 4 inches. For 4 inches and over 1 pipefitter and 2 helpers are used.

For extra-heavy (schedule 80) pipe and screwed fittings multiply by a factor of 2.

For schedule 120 pipe and screwed fittings multiply by a factor of 3.

The time required to test a piping system is generally based on a percentage of the total amount of labor-hours the job requires. The most accurate percentage to use is six.

Table 13–4. Installation of Vitrified Clay Pipe

Work element description	Unit	Man-hours/unit
Install vitrified clay pipe and fittings		
4 to 6 inches	joint[1]	.25
8 inches	joint[2]	.30
10 inches	joint	.50
12 inches	joint	.60
15 inches	joint	.95
18 inches	joint	1.1
21 inches	joint	1.25
24 inches	joint	1.4
30 inches	joint	2.00
36 inches	joint	3.5

[1] Joint size is 2 feet 6 inches.

[2] Joint size is 3 feet for all remaining pipe.

This table is based on a crew of 6 men for all pipe up to and including 21 inches. For larger pipe a crane and operator are needed, thus increasing the crew size to 7.

Table 13–5. Rough-In Plumbing

Work element description	Unit	Man-hours/unit
Install sewer pipe		
4 to 12 inches	feet	.45
Install cast iron drain lines and fittings		
4 inches	joint[1]	.85
6 inches	joint	1.00
8 inches	joint	1.30
Pipe work (steel) threaded pipe (schedule 40)		
1/2 to 3/4 inch	joint	1.00
1 inch	joint	1.16
1 1/4 inches	joint	1.24
1 1/2 inches	joint	1.36
2 inches	joint	1.6
2 1/2 inches	joint	2.00
3 inches	joint	2.4
3 1/2 inches	joint	2.8
4 inches	joint	3.2
Copper tubing[2]		
3/8 to 1/2 inch	joint	.5
3/4 inch	joint	.75
1 to 1 1/4 inches	joint	.9
Roughing work		
Lavatory	each	14
Water closet	each	16
Shower with stall	each	16
Slop sink	each	10
Urinal with stall	each	12
Bathtub	each	13
Kitchen sink	each	12
Bathtub with shower	each	19
Floor drain	each	6
Grease trap	each	8
Valves, faucets, etc., installed with rough plumbing		
1 inch or less	each	.5
1 to 2 inches	each	1.00
2 inches and over	each	1.25
Test plumbing system, per fixture		2 – 3

[1] A joint is the connection that joins pipe with pipe, pipe with a valve, pipe with a coupling, etc.
[2] Usually less than half as many joints will be required for copper tubing than for steel pipe of equal length.

This table is based on a crew of 2 men: 1 plumber and 1 helper.

13–6. Finish Plumbing

Work element description	Unit	Man-hours/unit
Install fixture including all trim		
Lavatory	each	8
Water closet	each	8
Slop sink	each	7
Residential hot water heater	each	12
Garbage disposal	each	5
Urinal	each	8
Bathtub	each	15
Urinal with stall	each	15
Footbath	each	10
Kitchen sink	each	11
Shower with stall	each	24
Bathtub with shower	each	22

This table is based on a crew of 2 men: 1 plumber and 1 helper.

Chapter 14

missing

CHAPTER 15

METAL WORK

15–1. General

Metal work includes erection of structural and miscellaneous steel, fabrication and erection of sheet metal, and fencing.

15–2. Structural and Miscellaneous Steel Erection

Erection of structural steel includes unloading, erecting, temporary bolting, plumbing, leveling, high strength bolting, and/or welding. Erection of miscellaneous steel includes unloading, setting in place, plumbing, leveling, and fastening (usually by bolting or welding).

15–3. Sheet Metal Work

Sheet metal work includes the fabrication and erection of gutters, downspouts, ridges, valleys, flashings, and ducts. Fabrication is usually performed in the sheet metal shop and includes making patterns, cutting, forming, seaming, soldering, attaching stiffeners, and hauling to site. Erection includes unloading, storing on site, handling into place, hanging, fastening, and soldering.

15–4. Install Fencing

Fence installation includes digging holes; unloading and distributing materials; setting, plumbing, alining, and concreting posts; installing braces; setting, stretching, and fastening fence fabric; installing caps and/or brackets on posts; installing gates, including hardware.

15–5. Estimating Tables

Tables 15–1 through 15–3 may be used in preparing detailed manpower estimates for metal work.

Table 15-1. Structural Steel Erection

Work element description	Unit	Man-hours/unit
Handling (unloading steel from truck to a ground location at the erection site)	ton	1.5
Erection of steel; erect, bolt, and plumb only[1]		
Foundation work	ton	5
Column and struts		7
Beams and channels		5
Plate girder		5
Crane rails		5
Knee braces		9
Floor plates		7
Fittings, bolts, rods, and anchor plates		3
Grits, angles, angle braces, purlins		7
Skylight frames and curbs		10
Monitor frames		12
Dormers		10
Door frames		12
Roof trusses		9
Transmission towers		16 - 30
Light steel trestles		12 - 24
Steel mill buildings		4 - 12
Steel frame multistoried buildings		3 - 10
Temporary bolting[2] (3 to 10 bolts/ton)	100 bolts	6
Bolting, high-strength (15 to 30 high-strength bolts/ton)	100 bolts	5
Riveting, air driven[3]		
On ground, easy work	100 rivets	8
Trusses	100 rivets	10
Steel office buildings	100 rivets	12
Steel mill buildings	100 rivets	12
Light trestles and towers	100 rivets	18
Riveting, hand driven		
Easy work	100 rivets	14
Difficult work	100 rivets	21
Welding[4] (5-10 feet of ¼ weld/ton)	100 lf	22

[1] For the erection of steel in these tables, the crew consists of 1 foreman, 1 crane operator, and 4 ironworkers. A crew size can vary considerably with respect to the different factors involved, and the user of these tables should take this into consideration.

[2] For bolting, the crew in this table consists of 4 bolters and 1 helper.

[3] The riveting crew size in this table is 5 men: 1 helper, 1 catcher, 2 riveters, and 1 helper to handle air compressor and hoses.

[4] Welding crew is 2 welders and 1 helper.

Table 15–2. Sheet Metal Work

Work element description	Unit	Man-hours/unit
Roof ridges[1]	100 lf	2.5
Roof valleys	100 lf	2.5
Roof flashing	100 lf	8
Roof gutters	100 lf	4
Downspouts	100 lf	4
Ducts[2]		
100 square inches or less[3]	10 lf	1 – 3
100 to 400 square inches	10 lf	2 – 5

[1] The crew for this portion of the table is 3 men: 1 skilled laborer and 2 helpers.

[2] The crew here is 1 mechanic (skilled laborer) and 1 helper.

[3] The size here means that in 10 feet of length the duct will have 100 square inches or less of surface area.

Table 15–3. Installation of Fencing

Work element description	Unit	Man-hours/unit
Completely install		
48-inch (height) chain link fence	10 lf	.75
6-foot chain link fence	10 lf	.85
8-foot chain link fence	10 lf	1.00

For 48-inch fence the crew size is 3 men. For the 6- and 8-foot fence the crew size is 4 men, the extra man being a tractor operator.

Chapter 16

missing

CHAPTER 17

MISCELLANEOUS

Section I. WRECKING AND SALVAGING

17–1. General

a. Only relatively simple techniques are currently used by the Army engineers to wreck structures. Far less effort is made to salvage construction materials than was formerly the case, since labor costs have increased relative to material costs.

b. Because of great variation in capacities among wrecking equipment, only the roughest labor estimates can be included here.

c. The salvage of marine vessels is a separate subject and is covered in TM 55-503.

17–2. Estimating Table

Table 17–1 may be used to prepare preliminary manpower estimates for wrecking and salvaging land structures. It does not provide for moving equipment to the site nor hauling salvaged materials.

17–3. Example of Table Use

a. The example below illustrates the use of table 17–1 in making a manpower estimate for wrecking and salvaging.

b. Sixteen wooden barracks are to be demolished. Salvageable material is minimal, but includes parts of furnaces. Labor is largely unskilled, but four crews can work simultaneously. Tractors are available. The estimator has decided to use average manpower estimates as given in table 17–1.

c. Each barracks contains 60 x 30 x 20 = 36,000 cubic feet, or 36 units. Since each unit requires 12 man-hours, total work estimate is 36 x 12 x 16 = 6,912. Thus, approximately 6,900 man-hours are needed to complete this task.

Table 17–1. Wrecking and Salvaging Structures[1]

Work element description	Unit	Man-hours/unit
Wood	1,000 cubic feet	12
Brick	1,000 cubic feet	20
Stone	1,000 cubic feet	24
Steel	1,000 cubic feet	18
Reinforced concrete	1,000 cubic feet	24

[1] Typical crew: 1 leader, 8 men.

Section II. SNOW REMOVAL

17–4. General

Snow removal includes the salting or sanding of roads and airfields, the plowing of roads and airfields by 5-ton dump truck with plow or grader, snowblowing, and the shoveling of sidewalks by men or garden tractor. Hauling of snow is not included because this activity is similar to earthmoving with front loaders and dump trucks (see chapter 6).

17–5. Selection of Equipment

Table 17–2 divides snowfalls into three types: light (under 2 inches), medium (2 to 6 inches), and heavy (over 6 inches). For light snowfalls, road trafficability can best be insured by spreading salt to melt ice or by spreading sand to provide traction. A salt truck spreads salt or sand most efficiently, although spreading can be done by shovelers spreading salt or sand from the backs of dump trucks. For a medium snowfall, graders, which are able to clear wide paths at relatively high speeds, are the most efficient snow removal equipment for main roads. Snowplows mounted on 5-ton dump trucks are used for secondary roads. For heavy snowfalls and large accumulations, snow blowers become a necessity in order to get the snow over the high banks which build up on both sides of the road. Plows are used to move snow to the sides of the road. While graders cannot handle heavy snowloads they are used continuously through the snowstorm to keep main roads open.

17–6. Estimating Table

Table 17–2 may be used to prepare preliminary manpower estimates for snow removal.

Table 17–2. Snow Removal

Work element description	Equipment	Unit	Equipment-hours/unit
Roads and airfields:			
Light snowfall (less than 2 inches) (salting and/or sanding)	salt truck	mile (15′ width)	0.20[1]
	dump truck & shovelers	mile (10′ width)	0.35[1]
Medium snowfall (2 to 6 inches) (plowing)	5-ton dump with plow	mile (6′ width)	0.15
	grader	mile (10′ width)	0.18
Heavy snowfall (over 6 inches) (plowing and blowing)	5-ton dump with plow	mile (6′ width)	0.25
	heavy duty blower	mile (6′ width)	0.15
Sidewalks:			
Light snowfall (less than 2 inches)	men	1,000 lf	1.8
	sidewalk tractor	1,000 lf	0.25
Medium snowfall (2 to 6 inches)	men	1,000 lf	2.0 – 4.0
	sidewalk tractor	1,000 lf	0.25 – 0.35
Heavy snowfall (over 6 inches)	men	1,000 lf	4.0 + 0.5 per inch over 6 inches
	sidewalk tractor	1,000 lf	0.35 + .06 per inch over 6 inches

[1] Includes refill time.

APPENDIX A

ABBREVIATIONS

A-1. List

ac	alternating current
amp	ampere(s)
bbl	barrel(s)
bhp	brake horsepower
Btu	British thermal unit(s)
cfm	cubic feet per minute
cfs	cubic feet per second
col	column
CPM	Critical Path Method
cu ft	cubic foot (or feet)
cwt	hundred weight (100 pounds US customary)
cy	cubic yard(s)
d	penny (nail measure)
dbhp	drawbar horsepower
dc	direct current
dwg	drawing(s)
ea	each
exc	excavate
ext	exterior
fbm	foot board measure
Fed spec	Federal specification
fpm	feet per minute
fps	feet per second
ft	foot (or feet)
ga	gage
gal	gallon(s) (US customary)
gpm	gallons per minute
hp	horsepower
hr	hour(s)
hz	cycle(s) (electrical) (hertz)
in.	inch(es)
int	interior
kva	kilovolt-ampere(s)
kvar	kilovar(s)
kw	kilowatt(s)
lb	pounds(s) (US customary)
lf	linear foot (or feet)
M	thousand
md	man-day(s)
Mfbm	thousand foot board measure
mh	man-hour(s)
min	minute(s)
mph	miles per hour
No. (or #)	number
oz	ounce(s)
pc	piece(s)
pcf	pounds per cubic foot
ph (or Ø)	phase(s)
pr	pair(s)
psf	pounds per square foot
psi	pounds per square inch
rcp	reinforced concrete pipe
S2S	surfaced two sides
S4S	surfaced four sides
sec	second(s) (of time)
sf	square foot (or feet)
SFCS	square feet of contact surface
sk	sack(s)
sq	square
sq in.	square inch(es)
sy	square yard(s)
tph	tons per hour
vc	vitrified clay
wk hr	working hour(s)
wt	weight

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